Recycler performance: status and outlook

Martin Hu

Recycler Department

Some apparent problems

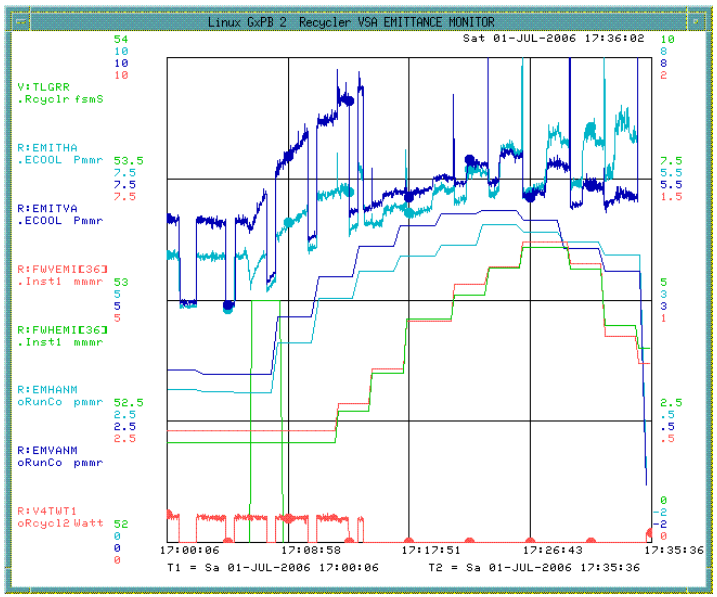
- Transverse emittance growth during mining/extraction (>100%)
- Longitudinal emittance dilution during RF manipulation (~15%)
- Uneven bunch intensity due to RF distortion (Up to 100%)

Transverse emittance

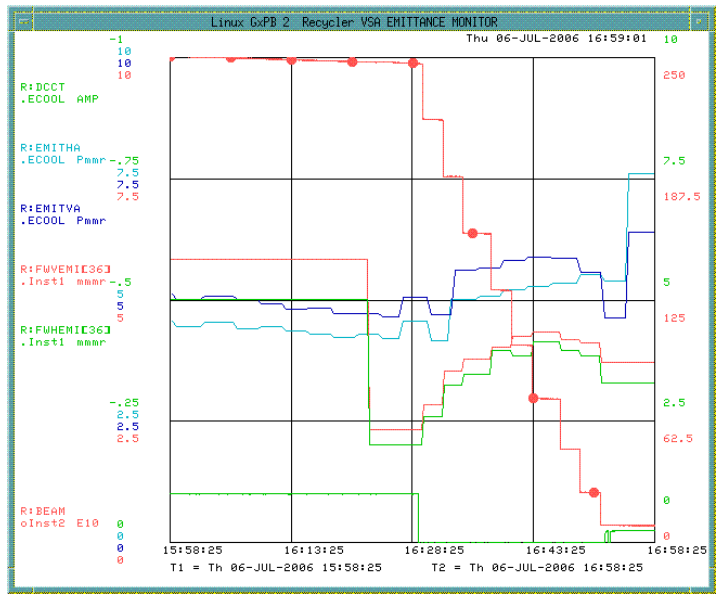
- Transverse emittances grow after momentum mining RF appears
- Only happens with pbars cooled by electron beam and stochastic cooling
- Only happens when there is high density
- Factors of 2~3 increase for worst cases
- Average impact on luminosity: 6 ~ 10%
- We have not totally understood the cause due to operational constraints
- Solutions:
  - Speed up momentum mining
  - Do not use momentum mining
  - Change tunes
  - Remove electron beam during mining/extraction?

Transverse emittances during extractions

Store 4807



Store 4815



Longitudinal emittance dilution during RF manipulation

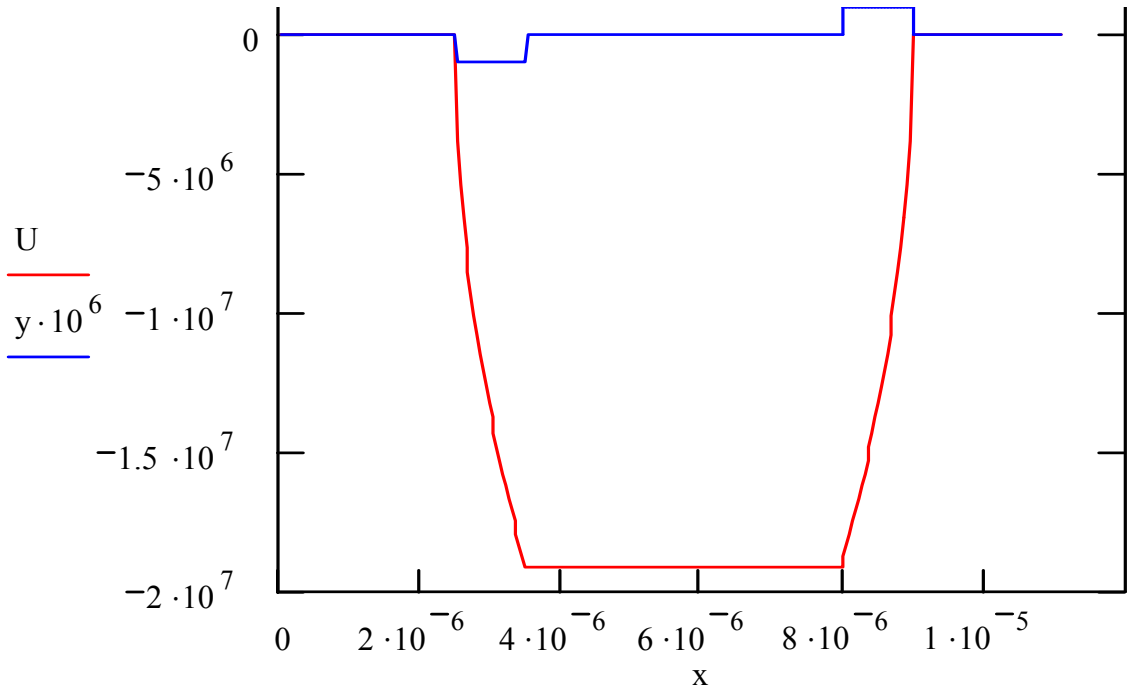
- From stretching a barrier bucket containing cold beam
- Due to very slow synchrotron frequency of particles in a barrier and finite speed of manipulation
  - Solution: change extraction algorithm to raise synchrotron frequencies
    - Bucket “accordionation”
    - “Strip mining”

Bunch unevenness in extraction with momentum mining

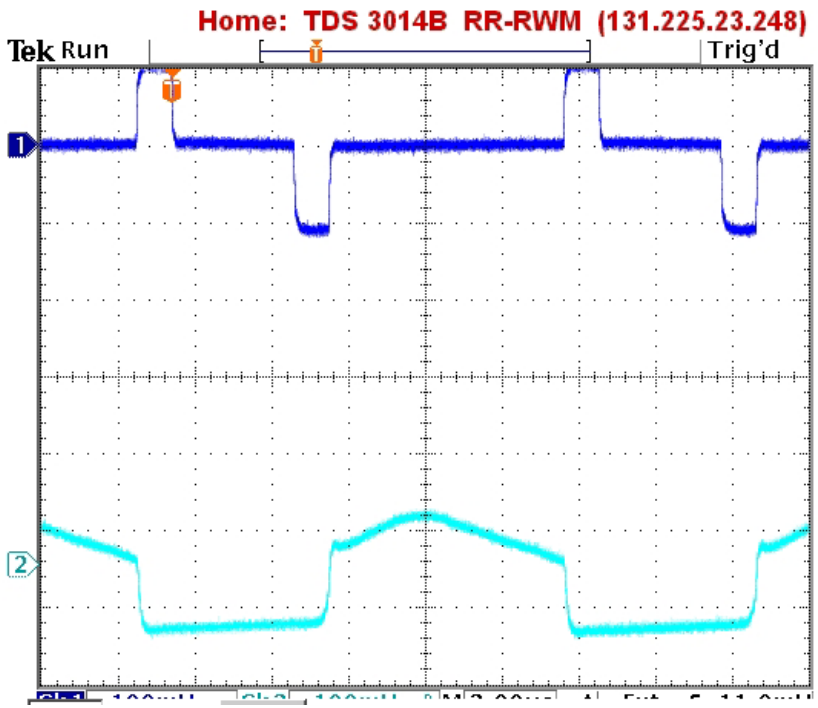
- Caused by potential well distortion
- Causes large variation in bunch intensity and numbers of pbars per transfer
- Proof based on cavity fan back voltage
- Made more apparent by small momentum spread
- Can cause stability problems
- Solution:
  - Feedback correction
    - In progress by Instrumentation/Recycler
    - Fast response compared to speed of RF manipulation
    - Takes care of beam loading automatically

Ideal barrier bucket

$$\Delta E_b(\tau) = -\sqrt{\frac{2\beta^2 E_0}{|\eta| T_0}\left|\int eV(\tau)d\tau\right|}$$

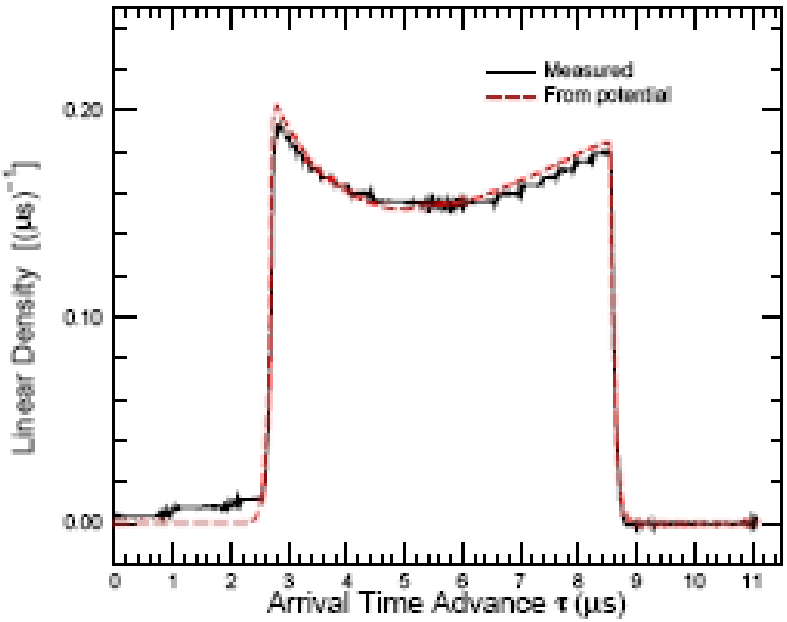


RF bucket distortion



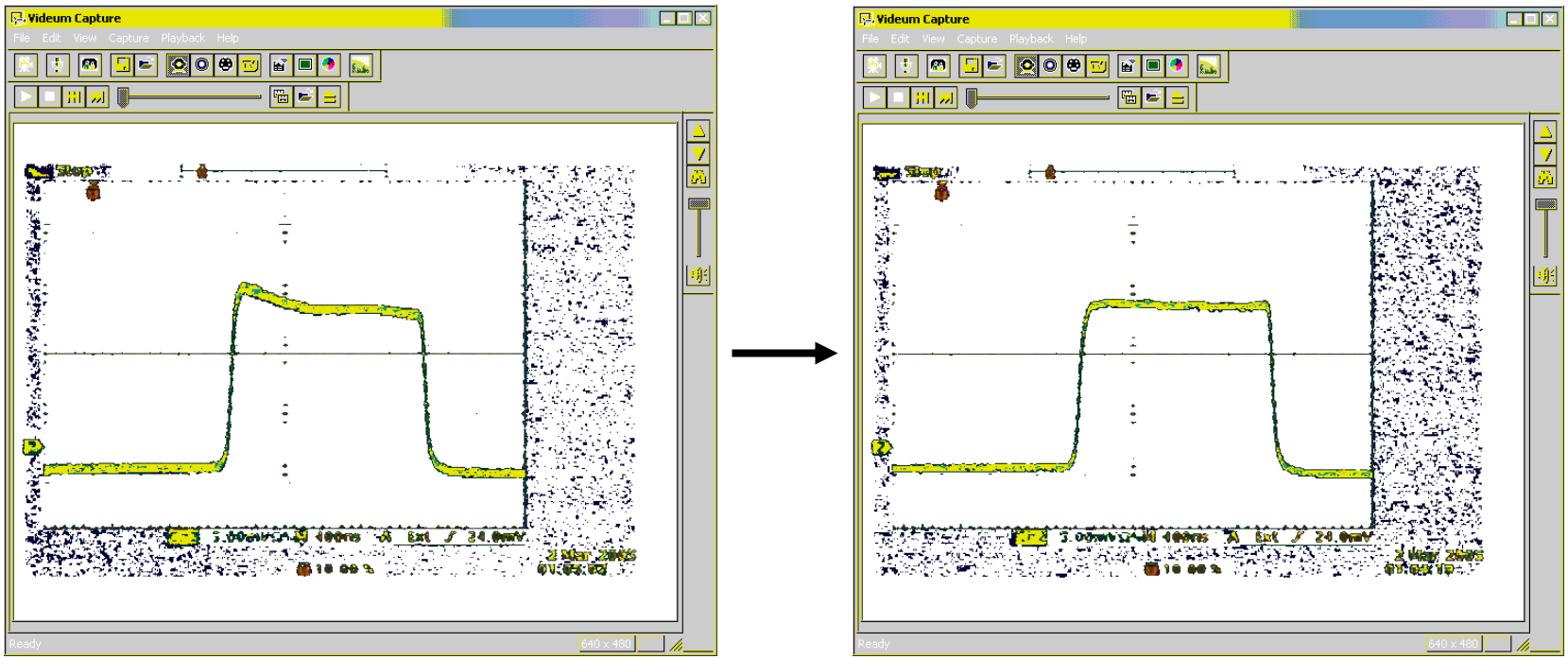
∫Vdt vs. RWM beam intensity

Figure 3: (Color) Beam profile computed from the rf fan-back voltage V_{eff} (red) agrees very well with the measured beam profile (shown in black).



J.Crisp, M. Hu, W. Ng, "Correction of Unevenness in Recycler Beam Profile", submitted to HB2006

Example of a feedback correction



Automatic fast correction

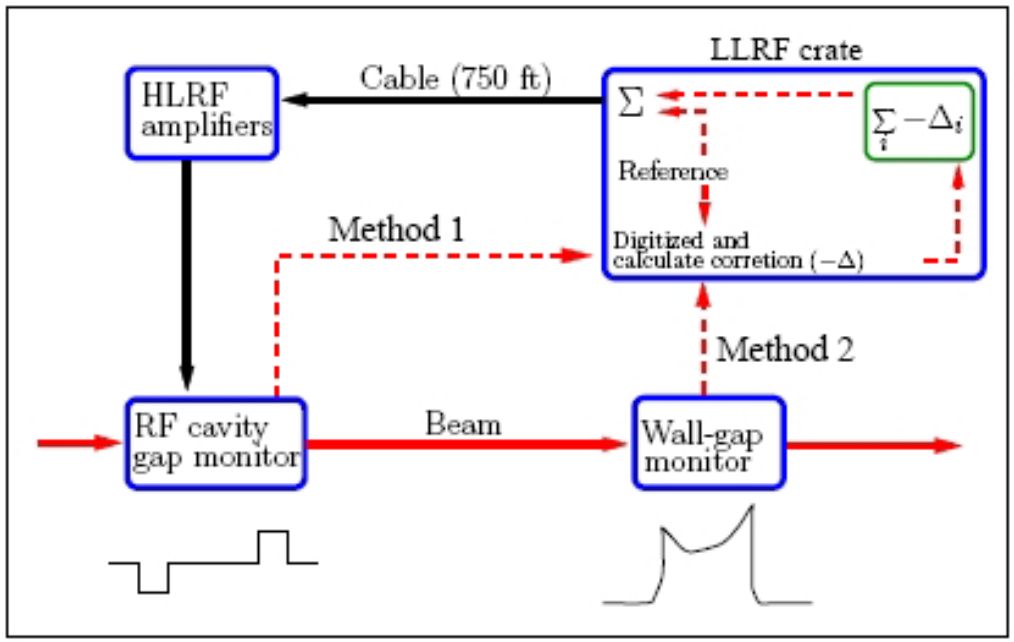


Figure 4: (Color) Block diagram showing correction to the beam profile unevenness through feedback. The rf fan-back gap voltage (Method 1) or the beam profile picked up by the wall-gap monitor (Method 2) is digitized, processed, compared with the reference, converted to suitable voltage table, and fedback to the LLRF.

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Conclusion

- We should be able to further improve the Recycler performance
- Transverse growth during momentum mining is the least understood
- Need to coordinate more non-destructive studies
- RF feedback looks hopeful; may be operational in a few months